Abstract

This thesis deals with the development of symmetric Singular Value Decomposition (SVD) algorithm in fixed-point format for power efficient embedded signal and image processing applications. Almost all signal and image processing algorithms are available in the floating-point format. Floating-point to fixed-point conversion of the algorithm requires 50 percent of the development time. Primarily there are two types of fixed-point algorithms available in the literature: constant and variable. The conversion process involves range estimation and word length optimization process to decide the integer and fractional word lengths. In constant format, the range is determined off-line after many iterations. In variable format range is estimated off-line from the statistics of the variables. However, these two formats cannot ensure no overflow for all possible set of data. A dynamic fixed-point format has been developed to determine the ranges of the variables on-line to ensure no overflow. Dynamic format exhibits better accuracy trend compared to constant and variable formats. Error propagation is also found to be negligible when a dynamic fixed-point algorithm is run. However, it has limitations. An analytical method is stated for computation of error propagation during arithmetic operations. SVD using Hestenes' algorithm, Lanczos with Divide and Conquer based approach are selected for the conversion process. Lanczos algorithm is a tridiagonal reduction method of dense symmetric matrices and it is known to be an important step in the computation of symmetric SVD. Lanczos algorithm with partial orthogonalization has been modified for real cases. Vector initialization has been simplified. These changes increase the execution speed of the algorithm. The fixed-point algorithm thus obtained may be utilized for different image processing applications such as eigenface preparation and subspace decomposition etc. Errors due to fixed-point conversion such as signal to quantization noise ratio, number of accurate fractional bits, orthogonality, and factorization errors are estimated and analyzed. In a case study of a real-time face detection and tracking with online learning, a system has been developed which is trained online and is customized for a face using fast SVD. The system is then capable of detecting and tracking the face in real-time.

Keywords: SVD, fixed-point, dynamic format, Lanczos algorithm, error analysis.